DOE/IHEA Materials Forum

Industrial Materials of the Future

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Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

Materials and Materials Processes

- Sara Dillich: Lead Technology Manager

Technology Managers:

- Mike Soboroff - Materials
- Elliott Levine – Glass
- Simon Friedrich - Metals

Industrial Technologies

MISSION

Improve the energy efficiency of U.S. industry through coordinated research and development, validation, and dissemination of innovative technologies and practices.

Partner with industry and other stakeholders to

- Reduce reliance on foreign oil
- Reduce environmental impacts
- Increase use of renewable energy
- Improve competitiveness
- Improve process yield/conserve resources
- Improve quality of life

OIT Priorities

- High-risk, high-return R&D with the potential to produce large improvements in energy efficiency, environmental performance, or product yield
- Integrated cross-cutting multi-industry R&D

Industries of the Future Strategy

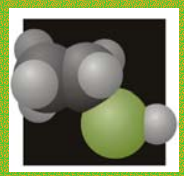
Technology for Today

Support RD&D for 9 energy intensive industries

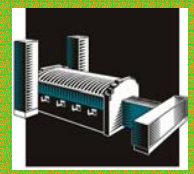
- Industry specific technologies
- Enabling technologies

Forest Products

Aluminum



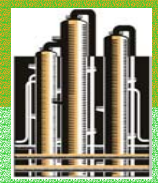
Chemicals



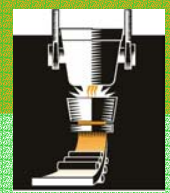
Glass

Metalcasting

Mining



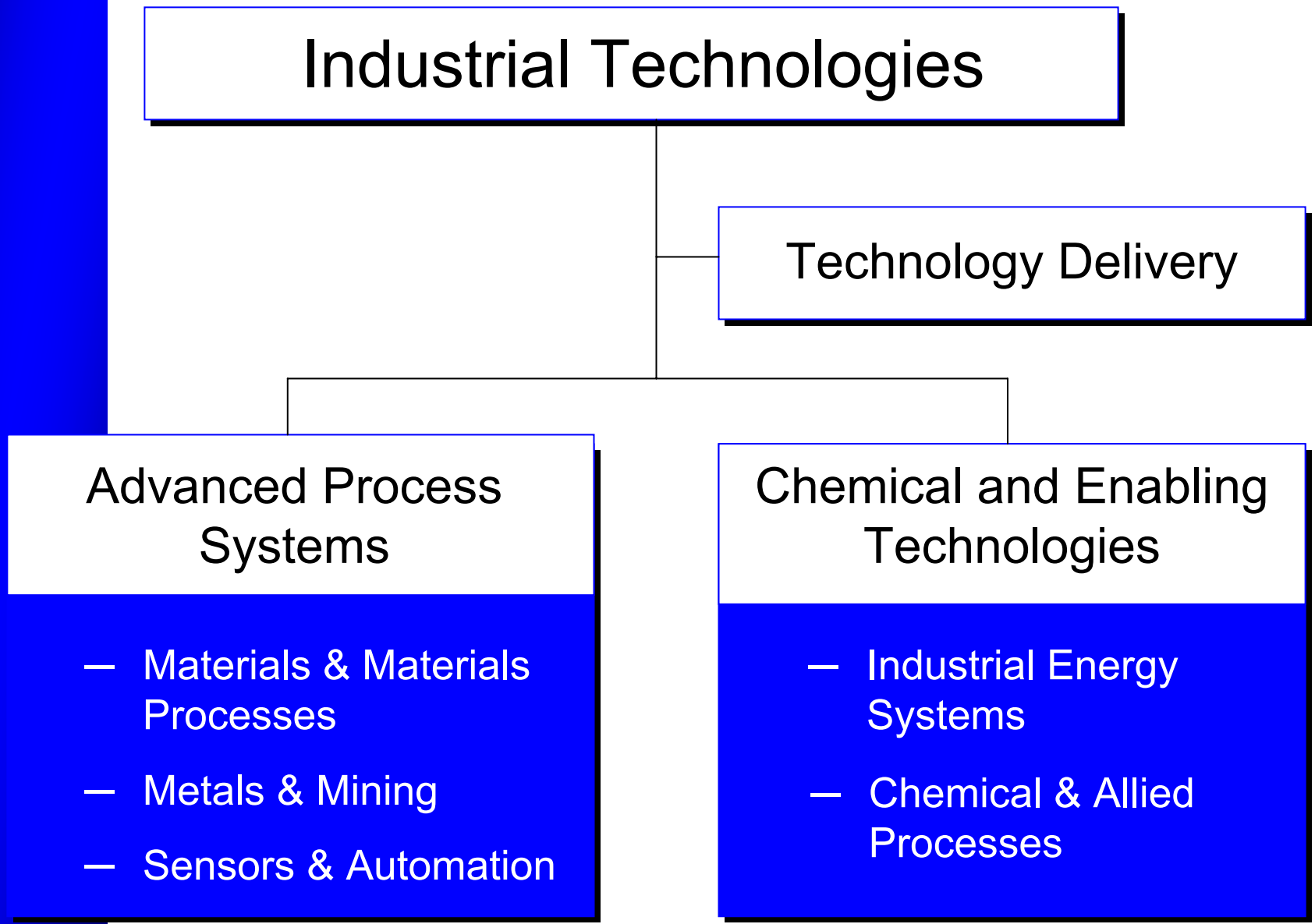
Petroleum Refining



Steel

Deliver Available Tools

Technology for the Future


Industrial Technologies
Technology Delivery
Advanced Process Systems
– Materials & Materials Processes
– Metals & Mining
– Sensors & Automation
Chemical and Enabling Technologies
– Industrial Energy Systems
– Chemical & Allied Processes

Industrial Materials for the Future

Mission - Lead a national effort to research, design, develop, engineer, and test new and improved materials for developing new advanced technologies to aid in energy reduction, as well as more profitable uses of existing materials, for the Industries of the Future

$12.7 M for 2003

IMF Core Research Areas

- Alloy development
- Materials database development/ High temperature properties
- Wear, erosion, and corrosion resistance
- Refractories
- Materials for sensors
- Materials for chemical separations

Provide opportunities for new materials and processing technologies to achieve IOF performance targets

IMF Portfolio – FY2003

- 27 active projects
- Factsheets on Projects can be found on website:

  www.oit.doe.gov

IMF FY2003 Portfolio

Alloy Development and Optimization

- Intermetallic Alloy Development
- New Class of Re-3Cr-W(V) Ferritic Steels
- Development of More Reliable Cast Austenitic Stainless Steels (H-Series)
- New Class of Bainitic Chromium- Tungsten Steels
- New Class of Ultra-Hard Borides

- Combinatorial Methods for Alloy Design and Optimization
- Inverse Process Analysis
- Stochastic Multi-objective Optimization
- Thermochemical Models and Databases for High Temperature Materials

IMF FY2003 Portfolio con't

Materials Processing and Synthesis

- High Density Infrared Treatment of Refractories
- High Density Infrared Transient Liquid Coatings
- High Energy Density Coating of High Temperature Advanced Materials
- Laser Surface Alloying of Materials
- Ultrasonic Processing of Materials
- Novel Superhard Materials and Nanostructured Diamond Composites for Multiple Industrial Application
- Advanced Nanoporous Composite Materials for Industrial Heat Applications
- Advanced Composite Coatings
- Ultrahigh Magnetic Field Processing of Materials for Developing Customized Microstructures
- Ultrananocrystalline Diamond Coatings for SiC Multipurpose Mechanical Pump Seals

IMF FY2003 Portfolio con't

Materials for Components

- Stress Assisted Corrosion in Boiler Tubes
- Ceramic and Refractory Components for Aluminum Melting and Casting
- Virtual Welded-Joint Design
- Zeolites for Energy-Efficient Hydrocarbon Separations
- Physical and Numerical Analysis of Extrusion Process
- High Performance Oxide-Dispersion-Strengthened Tubes
- Advanced Chlor Alkali Technology
- Advanced Tooling Alloys for Molds and Dies
- Carbon Films for Rotating Equipment

Process Heating

Advanced IR Heating Technologies

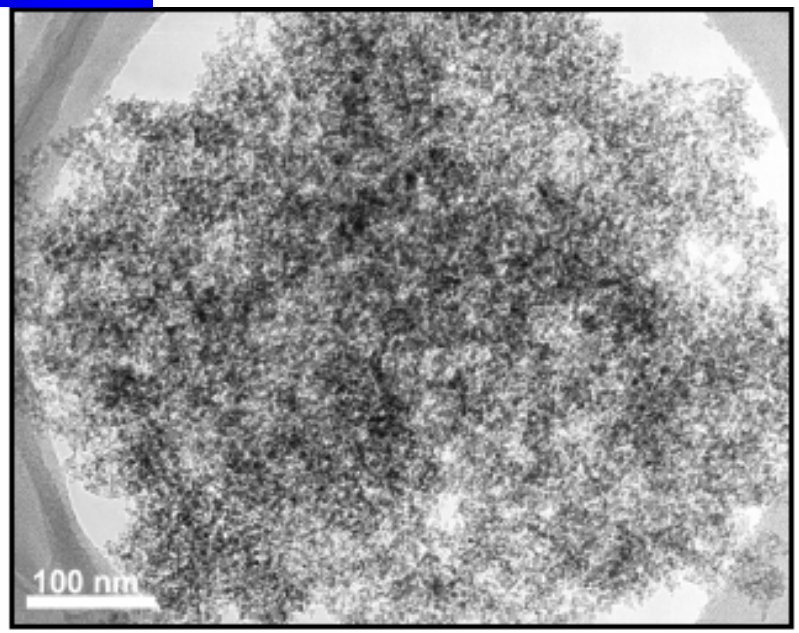
Die Heating and Surface Treatment

Steel Strip Preheating

- High electrical energy conversion (greater than 90% to heat)
- Improved Productivity
- Minimizes process heating losses
- Improves materials properties by limiting grain growth
- Being evaluated in steel, aluminum, heat treating, mining, and forging industries

Oak Ridge National Laboratory
Weirton Steel

ADVANCED NANOPOROUS COMPOSITE MATERIALS FOR INDUSTRIAL HEATING APPLICATIONS



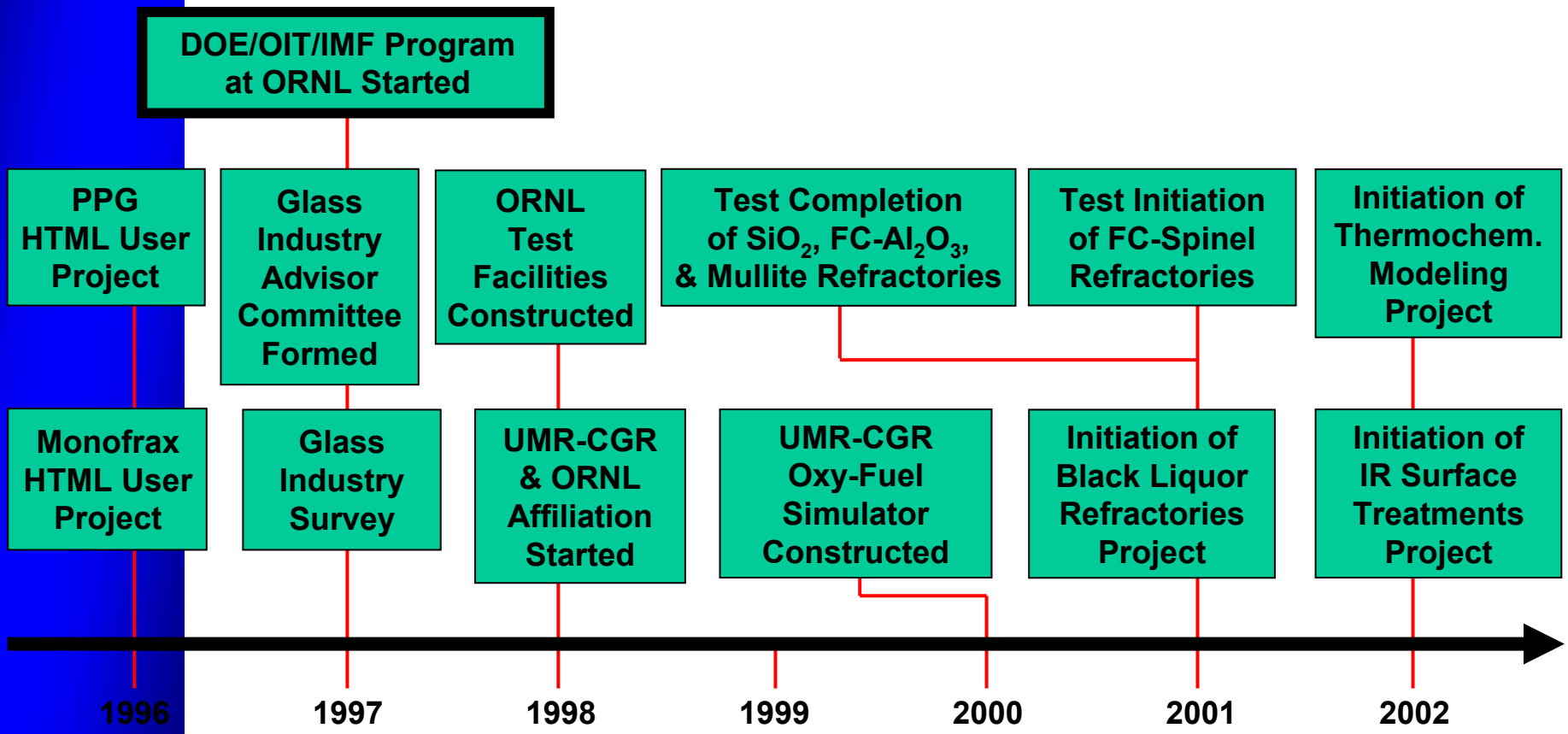
Electron micrograph of an aerogel-derived alumina-chromia composite material useful for high-temperature insulation applications. The image was obtained after a 60-minute heat treatment at 1000°C. The microstructure of the aerogel is relatively unaffected by the thermal processing.

- Improved insulating materials will reduce heat losses from furnaces, thereby reducing the energy required for industrial production processes.
- Improved performance from advanced refractory and insulating materials will increase the efficiency of primary energy use, reduce fossil fuel required to produce the energy, improve the lifetime of materials in process environments, and lead to environmental benefits (i.e., reduced
- CO2)

Lawrence Berkeley National Laboratory

Refractories

DOE-Industrial Technologies Program Funded Refractory Research and Development is Ongoing



HIGH-DENSITY INFRARED SURFACE TREATMENTS OF REFRACTORIES

Mullite Brick Surface Fused by the use of the HDI Lamp (Scan rate 1 cm/s at a radiant power of 800 watts/cm2)

- Reduced surface porosity (by essentially sealing the surface to prevent liquid penetration).
- Changed surface chemistry by either diffusing desired species into the surface or bonding of an adherent coating onto the underlying refractory (that would inhibit wetting and/or corrosion).
- Improved mechanical properties.

Oak Ridge National Laboratory

Allied Mineral
Emhart Glass
Kyanite Mining Corporation
University of Missouri-Rolla

Characterization and Structural Modeling of Magnesia-Alumina Spinel Superstructure Refractories are Underway

Present Goals:

- Quantify high temperature mechanical behavior
- Promote efficient design of furnace superstructure
- Enable energy and pollutant savings of oxy-fuel

Current Testing:

- Compressive creep at 1450-1650°C and 1-3 MPa
- Physical characterization (RLOM, CLI)
- Corrosion
- Thermal conductivity/diffusivity

Participants

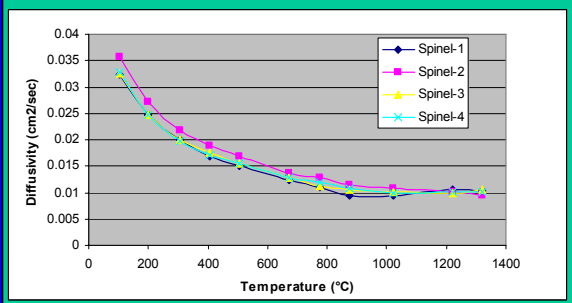
R&D Organizations

- ORNL
- UMR

Refractory Vendors

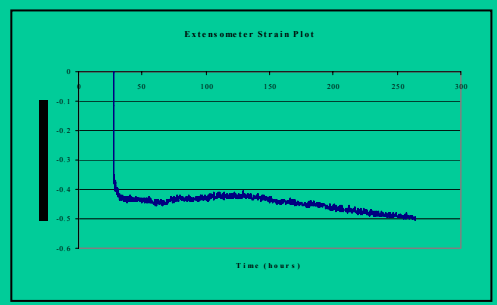
- Monofrax
- RHI
- SEFPRO

Thermal Diffusivity



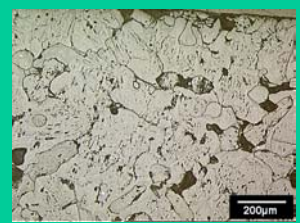
Bonded Spinel

Creep

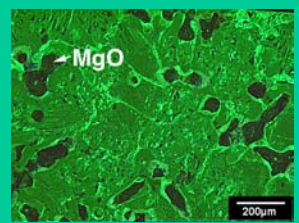


Fusion Cast Spinel

Reflected Light Optical Microscopy (RLOM)



Cathodoluminscence Imaging (CLI)



Bonded Spinel

R&D Funded by DOE/OIT/IMF Programs

DEVELOPMENT OF COST-EFFECTIVE LOW PERMEABILITY CERAMIC AND REFRACTORY COMPONENTS FOR ALUMINUM MELTING AND CASTING

Pyrotek fused-silica tube

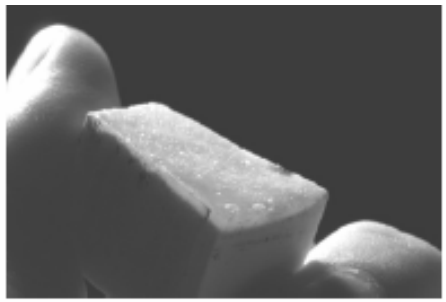
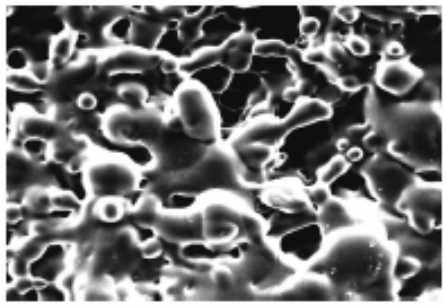


Photo of nozzle surface melted using ORNL high-intensity IR lamp



SEM photo of melted surface

Enhancement of the pressure-holding capacity of fused silica tubes and their implementation in aluminum melting and casting can lead to Significant energy benefits and Produce results that will also enhance the performance of refractories in the aluminum, glass, and chemical industries.

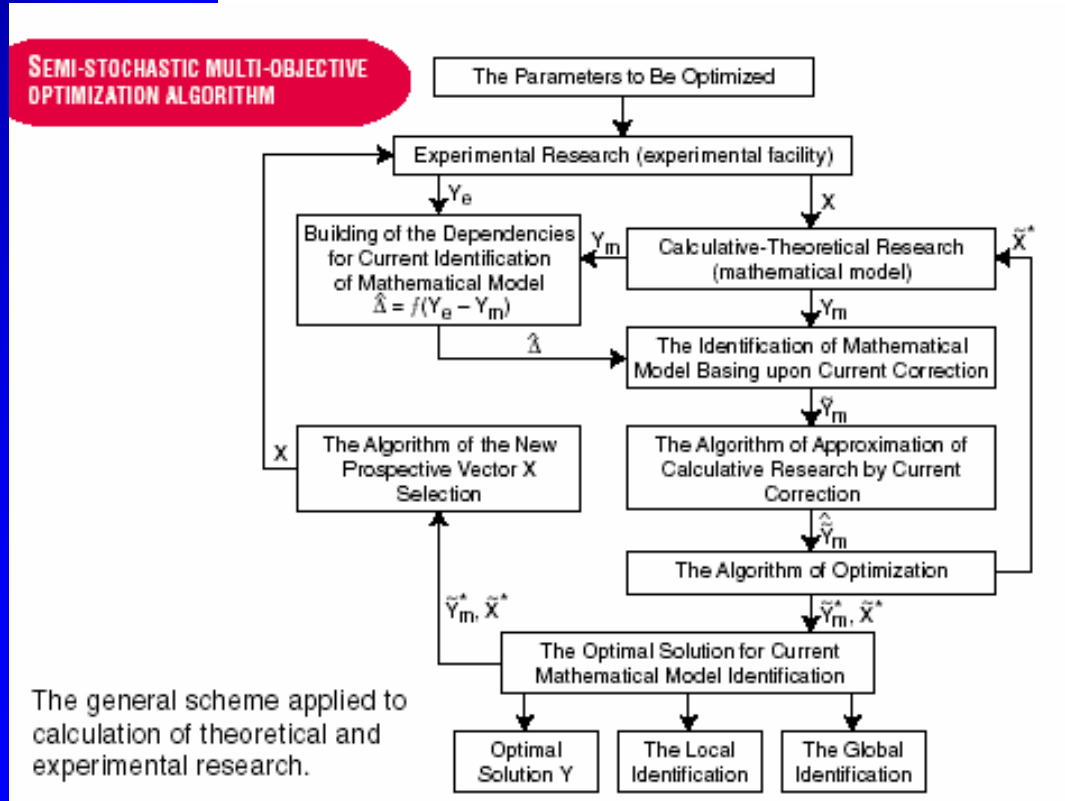
Pyrotek, Inc.

Oak Ridge National Laboratory
Progress Castings

University of Missouri Rolla

Degradation Resistance

STOCHASTIC MULTI-OBJECTIVE OPTIMIZATION OF HEAT- AND CORROSION-RESISTANT ALLOY PROPERTIES



The general scheme applied to calculation of theoretical and experimental research.

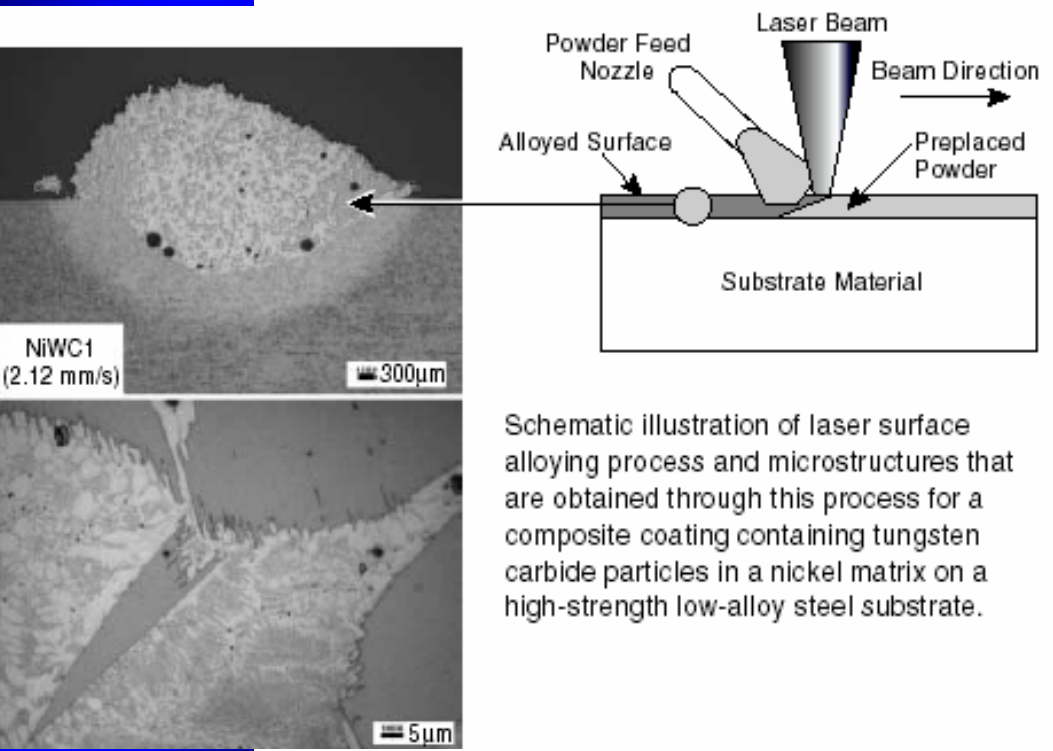
- A method to determine optimum concentrations of alloying elements in heat-resistant and corrosion-resistant H-Series austenitic stainless steel alloys that will simultaneously maximize a number of the alloy's mechanical and corrosion properties.
- A rigorous tool for the design of high strength H-Series steels
- Increased high-temperature strength by 50% and upper-use temperature by 30 to 60°C of H-Series of cast austenitic stainless steels.
- Improved energy efficiency through improved materials of construction.

University of Texas

Bethlehem Steel Corp.
Duraloy Technologies, Inc.
Energy Industries of Ohio

Oak Ridge National Laboratory
The Timken Company

Laser Surface Alloying and Materials Simulations



Schematic illustration of laser surface alloying process and microstructures that are obtained through this process for a composite coating containing tungsten carbide particles in a nickel matrix on a high-strength low-alloy steel substrate.

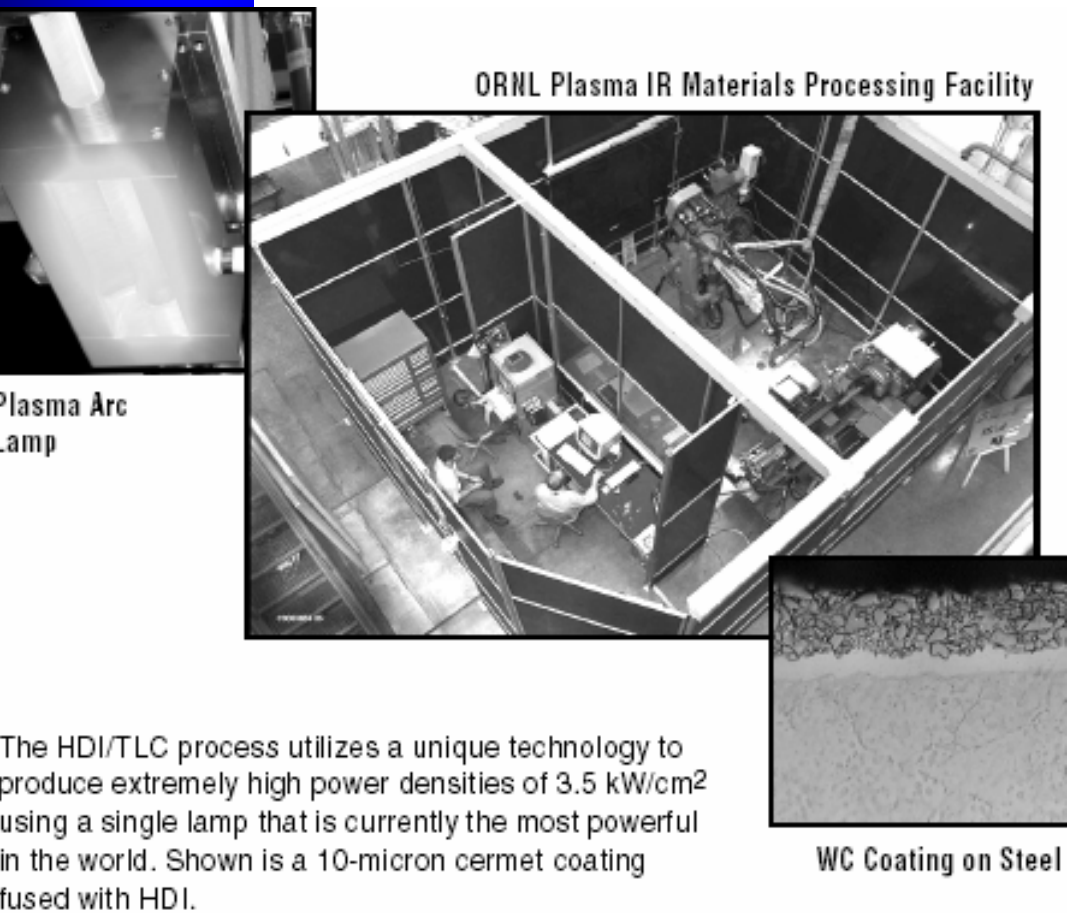
- Improved coating technologies will result in greater process efficiencies, improved performance, and extended life.
- Superior wear performance over a wide range of environments.
- Reduced downtime related to repair and refurbishment of worn and corroded critical components.
- Improved coatings will lead to energy savings through part life extension.

Applied Research Laboratory

ALSTOM Power Incorporated
Alvord-Polk Corporation
Oak Ridge National Laboratory

Praxair Surface Technologies
Spirex Corporation

HIGH-DENSITY INFRARED (HDI) TRANSIENT FUSED COATINGS FOR IMPROVED WEAR AND CORROSION RESISTANCE



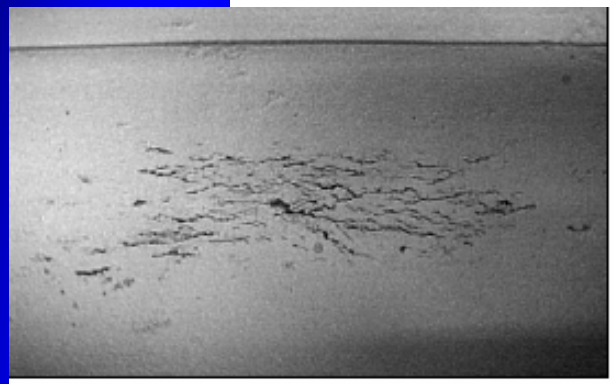
The HDI/TLC process utilizes a unique technology to produce extremely high power densities of 3.5 kW/cm^2 using a single lamp that is currently the most powerful in the world. Shown is a 10-micron cermet coating fused with HDI.

- The development of the HDI process and equipment for applying improved wear cermet coatings has significant potential to improve the energy efficiency of industrial applications.

Materials Resources, Inc. (MRi)

AmeTek
Carpenter Powder Products
Crucible Research Int'l
Lund International
Oak Ridge National Laboratory
St. Louis Metallizing

STRESS-ASSISTED CORROSION (SAC) IN BOILER TUBES



Inside surface of a boiler tube at a location exhibiting cracking.

Metallographic cross section of a cracked area; the cracks shown penetrate about 20% of the tube wall thickness.

- Improved awareness and control of SAC factors, which increases safety and efficiency by decreasing the frequency and duration of maintenance outages.
- Improve inspection schedules using risk-based assessments.
- Energy savings are estimated in excess of 20 trillion Btu's and a decrease of over 300,000 tons of greenhouse gases is anticipated per year 2020.

Institute of Paper Science and Technology

Babcock and Wilcox
International Paper
Mead Central Research

Oak Ridge National Laboratory
Westvaco

OIT Solicitations Now Open (www.oit.doe.gov)

- Industrial Materials of the Future – proposals due Feb 27th
- Sensors and Automation – proposals due March 31st
- Chemicals Industry of the Future – proposals due April 30th

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- Materials for sensors
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OIT R&D Portfolio Benefit vs. Risk